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Challenges to Technological Advancement in Economically Weak Countries: An Assessment of the Nigerian Educational Situation

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***Abstract*—**Nigeria is considered as one of the many countries in sub-Saharan Africa with a weak economy and gross deficiencies in technology and engineering. Available data from international monitoring and regulatory organizations show that technology is pivotal to determining the economic strengths of nations all over the world. Education is critical to technology acquisition, development, dissemination and adaptation. Thus, this paper seeks to critically assess and discuss issues and challenges facing technological advancement in Nigeria, particularly in the education sector, and also proffers solutions to resuscitate the Nigerian education system towards achieving national technological and economic sustainability such that Nigeria can compete favourably with other technologically-driven economies of the world in the not-too-distant future.

***Keywords*—**Economically weak countries, education, globalization and competition, technological advancement.

I. Introduction

THE main constituents of technology are basically Information and Communication Technology (ICT), and engineering. Technology has become central to human progress and interaction over the past century. More than ever before, it is becoming apparent that technology will remain a key factor contributing to economic growth and competitiveness on a global level. Advancements in technology have dynamically changed the world in the last few decades. Chen and Dahlman in a World Bank document highlight the importance of the use and creation of knowledge for long-term economic growth. The knowledge economy framework, which asserts that sustained investments in education, innovation, information and communication technologies, and a conducive economic and institutional environment will lead to increases in the use and creation of knowledge in economic production, and consequently result in sustained economic growth, was also introduced [1].

Presently, technological breakthroughs touch almost every aspect of human life. Examples abound for us to see in areas such as communication, transport, healthcare, banking and finance, housing, entertainment etc. One thing to note however is that there seems to be a disproportion in the spread of such advances in technology between the developed and economically weak countries. Dahlman argues that technology is an increasingly important element of globalization and of competitiveness and that the acceleration in the rate of technological change and the pre-requisites necessary to participate effectively in globalization are making it more difficult for many developing countries to compete [2].

If we critically examine the demands of the United Nations' Millennium Development Goals (MDGs) on economically weak countries, it would go without gainsaying that the majority of these countries, especially those in sub-Saharan Africa, will be most unlikely to meet up. Atchoarena and Delluc in a UNESCO publication stated that the effect of globalization on skills and future growth patterns of African economies are among the factors that will shape innovations in the field of technical and vocational education [3]. As such, in preparation for the challenges ahead, it must be ensured that young men and women willing to go into engineering and ICT as a profession are properly encouraged and given all necessary aid to do so. Irina Bokova, Director-General, UNESCO, commented in her foreword in a UNESCO report on challenges facing Engineering that it is estimated that some 2.5 million new engineers and technicians will be needed in sub-Saharan Africa alone if the region is to witness a substantial amount of progress towards achieving some of the MDGs [4].

As highlighted by the foregoing, Nigerian's placement and reckoning in the global network of technological advances must be seriously considered as this sole factor, now and in coming years, will become the yardstick by which economies of the world will be rated and sustained.

II. Technological and Developmental Growth in Nigeria

The majority of countries in sub-Saharan Africa in the colonial era had witnessed little advancements in technological growth as opposed to what was obtainable in the countries colonizing them. These countries, even after gaining independence, were majorly dependent on their colonial masters for their economic and technological sustenance. Today, the story is no different. It can best be said that the colonial lords of those days had no real interest in making their colonies self-sustaining and *independent*.

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A. Pre and Post-Independence Era

Before independence, the British government started giving some attention to research in a bid to improve indigenous technology This brought into being the establishment of institutions of higher learning, industries and research institutes, such that when Nigeria gained independence in 1960, it had a total of 389 established industries, a figure which was insufficient to serve the technological needs of the growing populace [5]. Most of these industries were forced into existence due to difficulty in obtaining manufactured goods from Europe during the World Wars.

Nigerian regional leaders after independence thus rightly perceived agricultural, educational and industrial growth as a means of enhancing competition between the regions and stimulating economic development. They therefore sought for ways of further improving existing local technology (which were chiefly at the most rudimentary level) through increased research, and also made policies that encouraged indigenous as well as foreign investment in the Nigerian economy [5]. However, since the initial impetus shown by Nigerian regional leaders in the early sixties which saw them taking full advantage of existing constitutional laws that granted some form of autonomy to regions, successive governments of the day have progressively defaulted in linking effective policy making to growth in knowledge and advancement in technology.

Two major factors were observed to affect technological growth and development in this era. The first was the dissociation of the four regions constituting the Nigerian territory into states by the military junta in 1967 and secondly, the discovery of crude oil in the region that is presently known as the Niger-Delta. The first event culminated in the loss of the competitive edge hitherto exhibited by the four regions caused by a basic shift in focus and ideology. The second resulted in a mono-economy that is basically dependent on revenues from crude oil. The first five years of the 'oil boom' witnessed rapid growth in infrastructure, industries and manpower development, but this initial growth could not be sustained because it only generated Dutch disease effects in the economy.

B. Recent Government Efforts to Aid Technological Growth

Since the late 1960s up till date, consecutive Nigeria governments, having realized the potential that a well-grounded technological backbone can incur at the global level for the country, have embarked upon four National Development Plans (NDPs) with numerous objectives tendered towards advancing technological development and globalization in Nigeria by the establishment of universities of technology whose sole aim was to 'expand research in the areas of science and technology' [5]. A number of ambitious national policies on science and technology intended to jump-start the Nigerian economy into a state of abysmal bliss has also been launched.

Additionally, numerous investors' fora have, and are still being organised, both in Nigeria and across international borders to attract investors from within and outside Africa to participate in building up the Nigerian economy by investing heavily in capacity building, technology transfer, research and development (R&D), and infrastructure. Most notable among these recent developments is Nigeria's budding relationship with countries in East Asia, especially China and Japan. For instance, the contractual agreement between Nigeria and the Chinese Civil Engineering Construction Corporation (CCECC) for the modernization of Nigerian Railroads was signed in July this year. It is to be noted that Japan and China are countries that have been able to make the transition from underdeveloped to developed nations over the past century. It however remains to be seen whether these collaborations will yield greater benefits than those earlier forged with the developed nations in Europe and the West.

The knowledge economy index for 1995 and most recent for selected (MENA) countries is presented in Fig. 1.

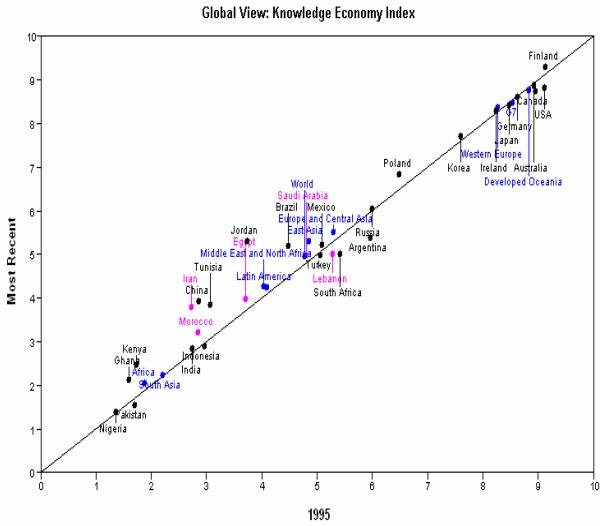

Fig. 1 Knowledge economy index: 1995 and most recent [1]

In recent times, many attempts have been made to diversify the Nigerian economy from its mono-economy outlook based on oil. According to a joint study by the United Nations Office of the Special Adviser on Africa and the New Partnership for Africa's Development - Organization for Economic Cooperation and Development (NEPAD-OECD) Africa Investment Initiative, economic diversification holds great potential to increase Africa's resilience and would contribute to achieving and sustaining long term economic growth and development in the continent. Broadly-based economies, active in a wide range of sectors, and firmly integrated into their regions, are better able to generate robust and sustainable growth [6].

Table I shows the annual growth rates and share of manufactured exports for both developed and developing countries [7].

TABLE I
ANNUAL GROWTH RATES AND SHARE OF MANUFACTURED EXPORTS

	Annual Growth Rates (1980-2000)			Share of Developing Countries	
	World	Developed	Developing	1980	2000
Total Exports	6.8	5.8	9.1	18.7	28.7
Primary	3.6	3.2	3.3	48.3	45.3
Manufactures, of which	7.5	6.2	13.2	9.6	26.9
Resource-based	5.6	4.5	8.5	15.1	26.1
Low Technology	7.0	5.0	11.6	16.5	38.3
Medium Technology	6.9	5.9	15.3	3.9	18.0
High Technology	11.4	9.6	20.4	6.8	32.2

It is therefore hoped that by giving a critical look at the challenges facing advancement of technology in the Nigeria terrain, and the concerted drive to meet up with global demands, we shall arrive at and define pragmatic solutions that can be adapted for use in other developing nations of the sub-Saharan region.

III. CONSTRAINTS IN TECHNOLOGY EDUCATION

The education sector in Nigeria is a much troubled sector that is currently facing a number of difficulties, most especially at the tertiary level. What is obtainable in most institutions of higher learning in Nigeria, particularly where engineering courses are being taught, is a pedigree of mediocrity that makes fair competition with universities in developed countries of the world almost impossible.

In the light of the preceding, it is instructive to note that no meaningful technological development can take place in the absence of an institutionalized policy on education. Salami argues that technological advancement and globalization have brought new training needs and manpower challenges that only tertiary education can satisfy. He thus advocates for a comprehensive revitalization of higher education in Nigeria such that workforce development partnerships needed to develop innovative approaches or replicate models that operationally demonstrate how a demand-technologically driven system can more effectively serve the desire of the nation in achieving economic development [8]. While this is in essence true, the relevance of proper teaching of mathematics and other science subjects in secondary schools with practical applications, upon which an admission into the engineering programmes of tertiary institutions are based cannot be overemphasized. Dahlman however noted that not all of knowledge is obtained from predictable means like R&D activities. A number of times, innovations may arise from insight, trial and error, or experience in production [2].

Education provides a major means by which knowledge is attained. According to the Encarta dictionaries, knowledge is the general awareness or possession of information, facts, ideas, truths or principles. Knowledge can therefore be created, acquired, adapted, and disseminated. Examples abound to show that the more educated the populace of an area or region is, the more technologically productive they seem to become. It has therefore become imperative that economically weak countries must seek technological knowledge by all means.

Major problems facing ICT, engineering and technical education in Nigeria include:

A. Deficient Curricula and Program Structure

Over the years, an overemphasis on teaching of theoretical concepts without the corresponding administration of practical exercises has gradually worn down the quality of engineering and science related courses. This practice is highly encouraged by majority of core academics in the sense that most do not attach much importance to allotting time for carrying out laboratory experiments as long as the theory (or some part of it) is in place – this probably being a result of their own inactivity in carrying out R&D forays in the laboratories, even with existing equipment and facilities. Given such circumstances, it is inevitable that students under such tutelage will develop negative attitudes towards practically oriented exercises. We therefore have a situation where majority of students are not able to relate and apply theoretical concepts to real-world processes. Additionally, the curricula adopted for use by institutions of higher learning (polytechnics and technical colleges inclusive) are majorly out of tune with what is relevant in the global world of technology today thereby making innovation extremely difficult.

Table II shows a comparison of average percentages between the present structure of engineering curricula in Nigeria and the existing structure of engineering curricula in America as at 1998 [9].

TABLE II
COMPARISON OF AVERAGE PERCENTAGES OF ENGINEERING CURRICULA IN NIGERIA AND AMERICA

Program	Nigerian Engineering Curricular (Present)	American Engineering Curricular (Existing)
Basic Sciences	15%	25%
Engineering Sciences	25%	25%
Technical Arts	8%	2.8%
Applied and Design Engineering	45%	22.2%
Humanities and Social Sciences	-	22.2%
Thesis	-	2.8%
Miscellaneous Subjects	7%	-
Total	100%	100%

It should be noted that in America, no time is allocated for courses on workshop, drawing and computer programming. The most probable reason for this is that most students who opt for engineering have done some workshop practice and computer programming at the high school level [9].

Object oriented languages used for modeling and simulation for developmental processes, especially where physical equipment are not available as is the case in most institutions in Nigeria, are hardly taught at lower levels except at the most peripheral plane, but are usually pushed to the final year of most engineering courses, possibly because would-be instructors are knowledge-deficient in these areas or

are hard to come by. Even where such knowledge is taught, you find that only about 15% - 20% of such a class will have defined capabilities.

Software engineering is another powerful tool presently being used in all parts of the developed world to bring about phenomenal changes to technology. Gone are the days when technology is routed through physical and mechanical means. These new trends in technology should therefore be properly harnessed, and must reflect in future curricula to enhance application and adaptations for technology education.

B. Uncoordinated and Inadequate Training of Students

Presently, engineering and most science–based courses in higher institutions of learning in Nigeria demand a certain amount of technical and industrial proficiency on the part of their students by packaging periods of Industrial Training (IT) at different levels of learning. As an integral part of the academic structure, the authors have seen the positive effects of this policy, but still consider that its implementation leaves quite a lot to be desired. One major difficulty is that students are expected to find placements by themselves, thus giving room for wide vagaries in the acquisition of skills and technical proficiency. In some instances, students are left stranded without any placement opportunities. Moreover, the program is bedeviled with lack of proper supervision and monitoring, absence of a streamlined expectation of the kind of experience each student is supposed to acquire, insufficient IT opportunities and lack of proper coordination between higher institutions of learning and the industrial sector.

C. Poor State of Equipment and Facilities

Core physical resources required for growth in technology are usually in form of up-to-date equipment in relevant fields especially for research work, well defined laboratory spaces and research centers, availability of software materials for developmental purposes and an enabling environment for innovative thinking. The present state of affairs shows that laboratories in tertiary institutions are ill-equipped to take on the challenge of evolving into such a condition that will present a launching pad for all future advancements in the development of technology, whether acquired or brought about through R&D. Some major problems include inadequate number of equipment which is exhibited in a very low percentage of student-to-equipment ratio, obsolete equipment even at point of supply, lack of proper and adequate training on equipment usage and maintainability especially in instances when the most up-to-date equipment are brought in, and the relegation of technologists, technicians, craftsmen and artisans.

A cursory inspection of laboratory conditions in any institution of higher learning today reveals that each unit of equipment is greatly outnumbered by the number of students available. This situation in itself is inimical to any form of useful learning since no room is left for personal experimentation and documentation. It is therefore not uncommon to find some students in their final year in school not having inculcated any laboratory experience or proffering any technical capability.

Because of the very fast pace at which technology is evolving, many developed countries are left with the burden of equipment they no longer find relevant to the technology needs of their countries. We therefore find quite a number of these equipment and machinery finding their way into the consumer markets of the less developed countries, – a situation which renders spare part replacement an encumbrance.

D. Inadequate Human Capacity Development

The importance of training and retraining on new developments in technology cannot be overemphasized. The authors of this paper sincerely believe that the training needs of ICT professionals, scientists, engineers, technologists, technicians, craftsmen and even artisans have to be taken beyond the scope of learning how to operate or maintain equipment to the realm of being able to conceive, develop and then implement ideas if Nigeria is to make any significant progress in breaking even in the global community. For example, human resources in engineering consist of engineers, technologists, technicians, craftsmen and artisans. Together, they are known as the engineering family [10]. One of the most important issues facing the development of human resources in Nigeria today is the relegation of technical staff not belonging to core academia. Aderoba further stated that all cadres of the engineering family must be properly educated and trained through the administering of proper scientific and technological methods and background, so as to be immediately productive in industry [10]. The situation existing today where these cadres of skilled workers are made to feel unimportant in the society and especially in the academia can only lead to a state of anarchy in the educational system and nullify the perceived effects of existing grandiose policies on technological independence.

E. Funding Issues

Education requires enormous amount of funding if it is to fully aid the realization of a country's developmental and economic goals. Research towards technological advancement in Nigeria has been basically unguided and considerably underfunded. In the Universities, lecturers and researchers initiate and conduct their research primarily to enable them to publish articles which will earn them promotions. The more esoteric and analytical the research, the more recognized it is in matters of promotion [10]. For the few who have some serious research ideas to implement, funding and the availability of suitable research facilities become a chief concern. No wonder then the mass exodus of research potential to universities and institutions in the developed world, leading to what is generally termed the 'brain drain' syndrome.

Reorganization of existing research centers as well as the establishment of more standard and functional ones at both national and regional levels in the sub-Saharan region is

fundamental. A major percentage of African students seeking postgraduate training outside the shores of the African continent presently can consequently remain within the shores of the African continent to carry out research that will be pertinent to the needs of the region while at the same time incorporating a globalized focus. Training and retraining of ICT professionals and engineering and scientific researchers and consultants would certainly mean making massive investments [11], both in the formal and informal educational sector. Provision of adequate infrastructure is major, especially in terms of acquisition of relevant and adequate equipment in higher institutions of learning and the replacement of non-functional equipment along with provision of quality and experienced instructors with applicable skills in relevant areas.

F. Lack of Government Support

The attitude of consecutive Nigerian governments towards supporting any form of local innovation leaves much to be desired. Universities and other institutions of higher learning in Nigeria as well as research institutes have been researching into areas of benefit to the economy for a while now and in many instances have been able to achieve some ground-breaking results. The failure of the Nigerian government to engage such research results (no matter how seemingly insignificant) for local use by rolling out the required machinery for adaptation of such knowledge for sustained mass production and information dissemination is alarming.

G. Defective Private Sector Participation

The role of the private sector in technological development in sub-Saharan Africa must certainly not be overlooked. In developed countries of the world, apart from the gigantic investments made by government in funding research dealing with advances in technology, the private sector also serves as a major driving force fuelling research in universities. The reverse seems to be the case in Nigeria. Much of the researches being done are privately funded (out of individual pockets, except in few cases where grants are available) and many times have no economic or global significance. The number of industry players partnering with universities to drive technological growth is at an all-time low. The major complaint coming from the private sector is the high cost of doing business in Nigeria, the cause of which can be attributed to the low level or non-availability of basic infrastructure - primarily stable electricity for production purposes, stiff tax regimes, insecurity, and unemployable graduates. The claim is that so much funds is spent on cushioning the effects of these negative factors that little is left for investment in technology development.

IV. Proffered Solutions

There is the general consensus worldwide that the large asymmetries existing between developed and developing countries, if not completely eradicated, must be greatly reduced. Nigeria must necessarily take a critical look at the internal dynamics and strategies of high performing East Asian countries which account for about 60 per cent of the developing world's population, about 75 per cent of its GDP and 93 per cent of its merchandise exports [3].

The authors hereupon proffer measures that if properly implemented will lead to drastic improvement in the economy and global relevance of the Nigerian state.

A. Sanitization of the Political Class

The first step towards achieving technological independence is the sanitization of the political class. A legacy of conflict and degeneration is often reflected by unstable governments. It will be observed that Russia went through a crisis and fragmentation with severe contraction of its GDP during the transition, and even a significant drop of life expectancy [2]. Though Nigeria's political terrain has remained stable for over a decade, internal fragmentations within the polity still remain issues of major concern. Leadership must therefore become sensitive and responsible to the expectations of its citizenry and the global community. Some of the processes that can be adapted to achieve this objective include:

1. Raising the level of education required to satisfy any quest for political office.
2. Making political office highly unattractive by grossly reducing the remuneration accruable.
3. Making political office holders accountable for their every action by overhauling the 1999 constitution and removing certain laws backing political vandalism.

B. Overhaul of the Education System

Given the problems facing the education sector as expatiated above, it becomes pertinent that a holistic analysis leading to a total overhaul of this sector is carried out.

1. Increased Funding

Huge funds will not only be required to facilitate acquisition of higher skills and learning, but also to retain skilled professionals in the system. Remuneration levels should be raised in order to encourage skill and knowledge retention. The Nigeria government should implement fully the 26 percent budgetary allocation of the total capital expenditure for a fiscal year to education as stipulated by UNESCO. This will go a long way to increase the level of learning and research activities that will promote technological advancement.

2. Reconstruction of Curricular and Program Structure

The curricular at all levels in various science and technology disciplines should be appraised, reviewed and tailored to solve local and global technological challenges. The new curricula must incorporate problem solving strategies that will force both instructors and students alike to depart from the existing status quo. Besides this, science and technology (S&T) students in higher institutions of learning should be exposed at an early stage to relevant courses in their chosen fields of

study in order to fast track knowledge assimilation.

3. Unconventional Knowledge Acquisition

A partial deviation from the traditional means of learning with a focus on providing manifold means of attaining skilled knowledge is imperative. This means that academics must depart from their present assumption of superiority and begin to harness skilled manpower within and outside the university walls, and also in the core industrial and ICT sectors. Technology-related ideas from non-science oriented students and individuals should also be encouraged. Effective use of distance education technologies, particularly the potential of internet based education and training services must also be extensively explored [2].

4. Life-long Learning

Life-long learning must be encouraged instead of the certificate-based knowledge acquisition predominant in Nigeria today. Adoption of this concept in policy making is recommended such that its implementation will result in high benefits even to the rural populace. Systems that will accommodate easy learning at any age and any level of professional proficiency must be accommodated.

5. Capacity Building

Crucial importance must be given to human capacity development in the education sector. The developmental needs of relevant personnel include comprehensive training and retraining if they are to attain the desired level of output and efficiency. A system for retaining highly trained and skilled individuals, whether in academics or otherwise, must be put in place to as to greatly reduce the incidence of brain drain which has become integral to the Nigerian situation.

Some of the countries in East Asia which are now classified as developed actually sent many of their national for specialized training in developed countries, brought them back, and then created the required infrastructure and enabling environment around them which aided them in achieving knowledge dissemination and impartation. We say Nigeria should do same.

Even though the importance of researches carried out within the African continent has been highlighted earlier, the authors believe that research collaborations with foreign partners in technologically developed nations should not be ruled out as this aids exposure to global best practices and technology transfer.

As part of the capacity building process, provision of adequate educational and social infrastructure is also paramount.

C. Private Sector Participation

No government can exclusively shoulder the responsibility of advancing technological development, more so Nigeria as a result of the state of her economy, coupled with huge financial commitments in other important sectors of national development. Hence, there is a dire need for major players in various sectors of the economy to further complement government effort by actively engaging the higher institutions of learning and research institutions to solve technological challenges that militates against their efficient operation in the areas of agriculture, manufacturing, oil and gas exploration and refining, telecommunications, construction, healthcare and energy. Also, more effort is expected from these key economy players through their corporate social responsibility activities which can be directed to promoting technological advancement. Establishment of well-equipped research laboratories in tertiary institutions, provisions of scholarships, research grants and student placements for Industrial training are all avenues that industry players can explore to help bridge the gap between classroom theory and real time applications.

V. Conclusion

Many of the core issues examined in this paper are not unusual in most economically weak countries of the world, notwithstanding peculiar circumstances and variations. Having considered the inherent problems in the Nigerian educational situation preventing growth in technology development, and the expected role of government in bringing about immediate and lasting changes, it goes without saying that Nigeria still has a long way to go. Previous blunders in policy formulation and implementation must be corrected. Corruption, the most detrimental factor thwarting any form of technological and economic growth, must be brought under control if not totally eradicated.

All cadres of professionals in the country must come together to forge a way forward and force government to make a definite commitment to technology acquisition, development, dissemination and adaptation. The prevalent thinking that a knowledge base in technology is only for the bright and brainy is outmoded and must be discouraged. Technology must be seen as everybody's business. Consequently, the governments and peoples of countries in sub-Saharan Africa must take up the challenge of advancing technological development in the respective home fronts so as to collectively bring Africa out of technological backwardness.

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